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Inventor: Brill

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SWITCHING EQUIPMENT

The present invention relates to a switching equipment and related method for ~~for a communication network according to the preamble of claim 1. In particular, the present invention relates to a switching equipment for~~ an ATM broadband communication network.

In communication networks, a plurality of switching equipment~~s~~, which serve as network nodes, are physically connected to one another via connecting paths. For purposes of setting up a connection between two users of the communication network, an appropriate connecting path, proceeding from the destination node, must be initially determined from the calling user to the called user.

In order the facilitate the determination of the appropriate connecting path (routing), the principle of ~~the~~ virtual connections has been invented, which is particularly applied in ATM broadband communication networks (asynchronous transfer mode). The transport of the data via the network is facilitated with the aid of ~~this principle of the~~ virtual connections and therefore is accelerated. According to the ATM standard, the data to be transmitted are transmitted in the form of cells, which generally comprise a control field (header) of 5 bytes and an information field (payload) of 48 bytes ~~Bytes~~. The sent ATM cells, corresponding to the bits of information prescribed in their headers, are passed through the communication network on "virtual paths" or "virtual connections" ~~(virtual path)~~. According to the principle of the virtual connections, the path to the destination is prescribed only once at the beginning. The individual switching equipment~~s~~ provides ~~provide~~ this desired switching path with a code that is valid respectively between two adjacent network nodes and allocates ~~allocate~~ the code to the connection. This code is respectively noted in the control field (header) of the cells (virtual path connection identifier, VPCI). Therefore, the switching equipment~~s~~ no longer has ~~have~~ to prepare the destination path anew when an ATM cell arrives; it ~~, but they~~ merely look at the code and thus knows ~~know~~ the desired destination. ~~They are called.~~

"~~virtual~~ Virtual connections", ~~since, in~~ contrast to real connections in the communication network, in that the transmission channel is not permanently busy for the duration of the connection, but the transmission channel is occupied only when data to be transmitted are actually present, i.e., that packets or cells of a connection are not transmitted without pauses during the entire connection time, but packets of other connections are forwarded in the pauses on the same transmission path at the same time.

What derives from the previously explained principle of the virtual connections is that a plurality of transmission channels are transmitted via a virtual connection (virtual path connection, VPC). Each transmission receives a ~~what is referred to as~~ virtual channel C ~~therefor (virtual channel~~, VC), so that a virtual path can comprise a plurality of virtual channels. The allocation of the virtual channels ensues in the network nodes, i.e., the individual switching equipments which is ~~, whereby~~, when a virtual channel is allocated or, respectively occupied, the resource (bandwidth) required for the respective transmission of the virtual channel must be occupied at the same time. The basic method for the occupancy of a virtual channel and therefore of the bandwidth for the respective connection is, according to the ITU-T recommendation Q.2764 (International Telecommunications Union), defined as follows:

A~~s it has already been explained above, a~~ virtual channel is prescribed between two adjacent network nodes or, respectively, switching equipments when the appropriate transmission path or, respectively, connecting path is prescribed. Only ~~Thereby, only~~ one of the two adjacent switching equipment~~s~~ is allowed to assign the virtual channel, and therefore the occupied bandwidth, in order to avoid a counter-occupancy of transmission channels and also in order to exclude a counter-occupancy of the bandwidth for the individual transmissions. In ~~It is configured in~~ each switching equipment is configured which of the connected connecting paths the respective switching equipment is allowed to assign a virtual channel and therefore a bandwidth to be occupied. The switching equipment authorized for allocating a virtual channel is called

an "assigning exchange", whereas the other switching equipment, in this case, is called a "non-assigning exchange". Each switching equipment monitors or, respectively, keeps track of the free or, respectively, occupied bandwidth of exclusively the virtual connections for which the switching equipment is configured as "assigning exchange". The administration of the free or, respectively, occupied bandwidth ensues in the form of a table, which is realized via ~~by means of~~ a file or another storage ~~storing means~~, and which is referred to as a "bandwidth pool".

A switching equipment, which is configured as a "non-assigning exchange" for a specific virtual connection, is not allowed to occupy a virtual channel for this virtual connection and therefore is not allowed to occupy a bandwidth for a connection request either. Particularly according to the prior art, a switching equipment is not to keep track of the free or, respectively, occupied bandwidth of virtual connections, for which it is configured as a "non-assigning exchange', i.e., that a "bandwidth pool" is not to be kept in the corresponding switching equipment regarding these ~~this~~ virtual connections, since the "bandwidth pools" that are simultaneously kept in the two switching ~~equipments~~ units would otherwise never be identical in the course of the switching traffic e.g., (particularly during the connection setup between the B-ISUP- messages "release message" (REL) and "release complete" (RLC)) ~~for example~~. Besides, the "bandwidth pools" would otherwise diverge due to different calculation algorithms in the two switching ~~equipments~~ units, which can result from having ~~stem from~~ different manufacturers or network providers; this is ~~would be~~ particularly serious when the bit rates are not constant.

The switching method, which has previously been proposed according to the ITU-T-recommendation Q.2764, is ~~subsequently~~ explained below in greater detail on the basis of Figure 2.

Figure 2 exemplary shows the section of a communication network with three switching ~~equipments~~ units 1 - 3, by which ~~whereby~~ in the present case, the switching equipment 1 is discussed ~~to be considered~~ in greater detail. The individual switching ~~equipments~~ units 1 - 3 are connected to one another respectively via a plurality of virtual connecting paths

(virtual path connection, VPC) 8 - 15. The switching equipment 1 comprises a central control device 6, which is responsible for processing incoming connection requests and for the corresponding connection setup to the other switching equipments 2 and 3. In particular, when a connection request is present, the control device 6 selects a suitable connecting path to an adjacent switching device 2, 3 and occupies - if possible - the bandwidth required for the connection request, i.e., that it allocates a virtual transmission channel to an adjacent switching device 2, 3. The switching equipment 1 comprises ~~storing means~~ storage 5, in which the function of the switching equipment 1 is configured. Particularly, the storage 5 stores ~~It is particularly fixed in the storing means 5~~ for which of the connecting paths 9 - 15, ~~which~~ that are connected to the switching equipment 1, the switching equipment 1 can become active, i.e., for which of the connected connecting paths 9 - 15 the switching equipment 1 itself is allowed to allocate a virtual channel and therefore is allowed to assign bandwidths. The ~~Let it be assumed, in the~~ present case assumes, that the switching equipment 1 is allocation-authorized for the connecting paths 9 - 11 and therefore is allowed to give the required bandwidth when a connection request is present. On the other hand, the switching equipment 2 is ~~be~~ allocation-authorized for the connecting paths 12, 13, whereas the switching equipment 3 is allocation-authorized for the connecting paths 14, 15, i.e., it is presupposed as an "assigning exchange". For example, it is also configured, in the storage ~~storing means~~ 5, via which of the adjacent network nodes a connecting path is generally to be set up when a connection request is present. For example, it can be fixed~~, regarding this,~~ that the switching equipment 1 always selects a connecting path via the switching equipment 2 when a connection request is present.

The switching equipment 1 also comprises storage ~~storing means~~ 4, which represents ~~represent~~ the previously described "bandwidth pool", i.e., that the storing means 4 store a table in which the free or, respectively, occupied bandwidth of all connecting paths connected to the switching equipment 1 is administered, for which bandwidth the switching equipment 1 is allocation-allocation-authorized and becomes active as "assigning

exchange". As it has already been explained, this is merely the case for the connecting paths 9 - 11 in the present case. As shown in Figure 2, the storing means 4 store the respectively occupied resources for each adjacent destination node 2, 3 and for each allocation-authorized connecting path 9 - 11, i.e. that they store the respectively occupied bandwidth, whereby each connecting path (virtual path connection, VPC) is identified by means of a corresponding identifier (virtual path connection identifier, VPCI). Each virtual connecting path can comprise a plurality of virtual channels that have been allocated by the switching equipment 1 to this connecting path, so that the table (bandwidth pool) stored in the storing means 4 considers the virtual channels allocated for each connecting path with the aid of an identifier (virtual channel identifier, VCI) and considers the bandwidth that is respectively occupied for the corresponding virtual channel.

When a connection request is present, which is supplied to the switching equipment 1, for example, via a further connecting path bundle 7 of a further (not shown) adjacent switching equipment, a suitable connecting path and a suitable transmission channel are fixed as follows:

As soon as the switching equipment 1 receives a connection request, the switching equipment 1 is initially to try to occupy a connecting path, for which the switching equipment 1 is configured as "assigning exchange", with an appropriate transmission channel and to assign the bandwidth required for the connection request. This ensues by means of evaluating the table deposited in the storing means 4. For example, when a connection request is present that would occupy approximately 40 % of the bandwidth available in total on the connecting path 9, the switching equipment 1 could select the connecting path 9 for the desired connection and could allocate a virtual channel VCI-C and assign the bandwidth given the situation shown in Figure 2. The transmission of control messages between the individual switching equipments 1 - 3 ensues according to the B-ISUP signalization protocol, so that the switching

equipment 1, subsequent to the allocation of a virtual channel, informs the switching equipment 2 about the selected connecting path and the allocated transmission channel (potentially the occupied bandwidth) in the form of corresponding identifiers (virtual path connection identifier, VPCI and virtual channel identifier, VCI), whereby this ensues in the form of the first B-ISUP-forward message (initial address message, IAM).

On the other hand, when the switching equipment 1 was not able to detect a suitable transmission channel in the connection paths 9 - 11 for which it is configured as "assigning exchange", the connection must ensue via one of the connecting paths 12 - 15, for which the switching equipment 1 is configured as "non-assigning exchange". In this case, the switching equipment 1 is not allowed to allocate a transmission channel and is not allowed to assign bandwidth for the desired connection, but must inquire the adjacent switching equipment 2, 3 about the required bandwidth. For this purpose, the switching equipment acting as "non-assigning exchange" does not insert identifiers into the B-ISUP-forward message IAM via the selected connecting path and the allocated transmission channel (VPCI, VCI) and sends this B-ISUP-forward message to one of the adjacent switching equipments 2, 3. This ensues without the switching equipment 1 having bits of information about whether the bandwidth required for the desired connection can be provided by the corresponding switching equipment at all. After receipt of the requests for the allocation of a transmission channel, the corresponding switching equipment 2, 3, if possible, allocates a transmission channel on one of the connecting paths, for which the corresponding switching equipment is configured as "assigning exchange", to the desired connection. For example, when the switching equipment 1 has transmitted a request for allocating a transmission channel to the switching equipment 2, the switching equipment 2 can search for an appropriate transmission channel merely on the connecting paths 12 and 13. When the switching equipment 2, in this case, is able to allocate an appropriate transmission channel on the connecting paths 12 and 13, the switching equipment 1 is informed of the selected

connecting path and of the selected transmission channel in the form of the identifiers VPCI, VCI by means of the switching equipment 2 in a corresponding first B-ISUP-return-message, which is referred to as "initial address message" (IAM).

The following problems result from the previously described course of action:

As it has already been explained, each switching equipment 1 merely has bits of information about the bandwidth available on the connecting paths for which the respective switching equipment has been configured as "assigning exchange", namely for which the respective switching equipment is authorized for allocating a transmission channel and for occupying corresponding bandwidth. For example, when the switching equipment 1, in Figure 2, is not able to find an appropriate connecting path among these connecting paths for a present connection request, the occupancy message, namely the request regarding the occupancy of a transmission channel, is simply sent to the first best adjacent switching equipment 2, 3. This ensues without knowing whether the respective adjacent switching equipment 2, 3 provides sufficient resources for the desired connection. When the adjacent switching equipment 2, 3 contacted by the switching equipment 1 is not able to provide the required bandwidth on the connecting paths for which the switching equipment 2, 3 is configured as "assigning exchange", the connection request is rejected by means of a B-ISUP-return-message IAR (initial address reject). In this case, the switching equipment 1 tries again and inquires another one of the adjacent switching equipments 2, 3 about whether it can provide a suitable connecting path for the desired connection (re-routing). Generally, the number of these re-routing processes is limited to one trial, so that a re-routing via a third connecting path can basically not result. However, the resources on the connecting paths, for which the switching equipment 1 is configured as "non-assigning exchange", cannot efficiently be used as a result thereof. Further, what derives from the previously described course of action is that the likelihood of a successful connection setup due to the fact that the switching equipment 1, for the case

that it itself cannot detect a suitable connecting path, is reduced and that a 'blind traffic' can occur. However, when a suitable connecting path between the switching equipment 1 and an adjacent switching equipment 2, 3 is not found, all connecting paths that have already been set up before the switching equipment 1, would have to be retroactively released, namely cleared down; this is extremely complex.

Finally, it also derives from the previously cited reasons that a switching equipment should not be configured as "non-assigning exchange" for all connecting paths present between two switching equipments, since this would be extremely inefficient for a successful connection setup.

Therefore, the present invention is based on the object of fashioning a switching equipment of the species cited above such that the likelihood of a successful connection setup and the efficiency of the connection setup is increased.

According to the present invention, this object is achieved by means of the features cited in claim 1. The subclaims describe advantageous and preferred exemplary embodiments of the present invention.

According to the present invention, the connection path search, namely the "routing" is fashioned significantly more efficient in that the switching equipment also keeps bits of information about the momentary occupancy of the connecting paths for the connecting paths, for which it is configured as "non-assigning exchange". In particular, these bits of information are deposited in the form of a data shadow table ("shadow bandwidth pool"). When the switching equipment is not able to detect a suitable connecting path among the connecting paths for which it itself is configured as "assigning exchange", the switching equipment, on the basis of the bits of information stored in this shadow table, can select an adjacent switching equipment that provides, with great probability, sufficient resources for the connection request. Adjacent

switching equipments that are likely not to be able to provide the required bandwidth are not taken into consideration for the "routing process" at all.

As a result of this embodiment of the present invention, the number of the successful connection trials can be significantly increased in the case that the switching equipment cannot detect any suitable connecting paths, for which it itself is configured as "assigning exchange". The blind traffic, which is conditioned by hopeless connection setups, is significantly reduced and the efficiency of the path search is considerably increased.

The invention is subsequently explained in greater detail on the basis of a preferred embodiment. Shown are:

Figure 1 the exemplary construction of a preferred embodiment of a switching equipment according to the present invention, and

Figure 2 the exemplary construction of a known switching equipment for an ATM communication network.

The invention is subsequently explained on the basis of a preferred embodiment upon reference to Figure 1, whereby the differences of the present invention vis-a-vis the known switching equipment shown in Figure 2 are particularly represented. The switching equipment shown in Figure 1 is based on the switching equipment shown in Figure 2, so that the previously described way of functioning of the known switching equipment is expressly referenced here.

The switching equipment 1 shown in Figure 1 functions in a way, which is known per se, as it has previously been explained on the basis of Figure 2. However, the critical difference of the present invention vis-a-vis the known switching equipment is the fact

that, according to the present invention, the switching equipment 1 also stores bits of information about the occupancy of the connecting paths that are connected to the switching equipment 1, for which connecting paths the switching equipment 1 is configured as "non-assigning exchange", namely for which the switching equipment 1 is not authorized for the allocation of a transmission channel (virtual channel, VC) and for the corresponding occupancy of the bandwidth when a connection request is present. Given the exemplary embodiment shown in Figure 1, this is particularly the case with respect to the connecting paths 12 - 15, whereby the switching equipment 2 is configured as "assigning exchange" concerning the connecting paths 12, 13 and the switching equipment 3 is configured as "assigning exchange" concerning the connecting paths 14, 15, and only the switching equipment 2 or, respectively, 3 is allowed to allocate a transmission channel and a corresponding bandwidth when a connection request is present about these connecting paths 12 - 15.

The switching equipment 1 administers the bits of information about the occupied resources of the respective connecting paths, for which it is configured as "non-assigning exchange", in the form of a shadow table that is deposited in further storing means 16. This shadow table can be particularly realized in the form of a file or in the form of a physical storage unit. This shadow table ("shadow bandwidth pool") is essentially analogously structured to the table ("bandwidth pool") deposited in the storage means 4, which table administers the connecting paths 9 - 11, for which the switching equipment 1 is configured as "assigning exchange". This means that the momentary occupancy of the individual connecting paths 12 - 16 and the virtual channels ("virtual channel, VC) momentarily allocated via these connecting paths are also defined in this table, which is deposited in the storing means 16. Each connecting path is identified in the form of an identifier ("virtual path connection identifier, VPCI), and the transmission channels that are momentarily fixed via this connecting path are specified in the form of "virtual channel identifiers, VCI" for each connecting path. Further, the table deposited in the storing means 16 contains how many resources are

momentarily occupied by the respective connection. For example, it is stored in the storing means 16 that the transmission, which is specified by means of the identifier VCI - C, momentarily occupies 80 % of the bandwidth available via the connecting path 12 (VPCI = 12). Corresponding bits of information are kept for all other connecting paths 12 - 15, for which the switching equipment 1 is not authorized for the allocation of a transmission channel and for the occupancy of bandwidth.

For example, when the switching equipment 1 receives a connection request via the connecting path bundle 7, the switching equipment 1 initially tries - as it has already been explained on the basis of Figure 2 - to act as "assigning exchange", i.e. that the switching equipment 1 tries to occupy a suitable transmission channel and a corresponding bandwidth in the connecting paths, for which the switching equipment 1 is configured as "assigning exchange". In the present exemplary embodiment, this is the case regarding the connecting paths 9 - 11. When a suitable connecting path, which provides sufficient resources for the desired connection, has been detected by the switching equipment 1 from the connecting paths 9 - 11, the switching equipment 1 allocates a transmission channel to the desired connection on the detected connecting path and occupies the required bandwidth. The switching equipment1 subsequently informs the corresponding adjacent switching equipment 2 or 3, in the form of the first B-ISUP-forward message, namely in the form of the what is referred to as IAM-message ("initial address message"), of the "virtual path connection identifier" (VPCI) and the "virtual channel identifier" (VCI) of the occupied channel. To that extent, the function of the inventive switching equipment shown in Figure 1 corresponds to the function of the switching equipment that is already known (compare Figure 2).

However, when the switching equipment 1, on the basis of the connecting paths 9 - 11 for which the switching equipment 1 is authorized for the allocation of a transmission channel and for the occupancy of bandwidth, is not able to detect a suitable connecting path that provides sufficient resources for the desired connection, the switching

equipment 1 must act as "non-assigning exchange" and must inquire one of the adjacent switching equipments 2, 3 about the required bandwidth. This means that the switching equipment 1 must detect a suitable adjacent switching equipment 2, 3 that acts as "assigning exchange" for one of the connecting paths connected to the switching equipment 1. In the exemplary embodiment shown in Figure 1, this is particularly the case with respect to the connecting paths 12 - 15. In order to detect an adjacent switching equipment 2, 3 appropriate therefor, the control means 6 of the switching equipment 1 access the bits of information deposited in the storing means 16, namely access the shadow table (shadow bandwidth pool).

The control means 6 search the bits of information deposited in the storing means 16 for an adjacent switching equipment 2, 3 that is highly likely to be able to provide the bandwidth required for the present connection request. Further, it can be additionally considered, for purposes of detecting the adjacent switching equipment to be contacted, which of the adjacent switching equipments 2, 3 offers the shortest connecting path. This default is normally deposited in the storing means 5, since - as it has already been explained on the basis of Figure 2 - it is configured, already at the beginning of the initial operation, via which adjacent switching equipment a connection setup should normally ensue.

Let is be initially assumed, in the present case, that a connection request, which would occupy approximately 20 % of the resources available in total on one of the connecting paths 9 - 15, is present at the switching equipment 1. Given the situation shown in Figure 1 and the table content of the storing means 4 and 16 shown in Figure 1, this would mean that the switching equipment 1 initially searches the table content (band width pool) of the storing means 4 for an appropriate connecting path.. Since merely a total of 70 % of the connecting path 9 are momentarily occupied by the transmission channels VCI-A and VCI-B, the connecting path 9 still provides sufficient resources, namely a sufficient bandwidth, for the desired connection request. As a result thereof,

the switching equipment 1 can select the connecting path 9 as suitable connecting path for the desired connection and, for example, allocates the transmission channel with the "virtual channel identifier" VCI-G to the desired connection. The switching equipment 2 is subsequently informed of the bits of information VPCI=9 and VCI=VCI-G in the form of the first B-ISUP-forward message.

Subsequently, let it be assumed that the connection request at the switching equipment would occupy, for example, 50 % of the bandwidth respectively available in total on the individual connecting paths 9 - 15. In this case, the switching equipment 1 or, respectively, its control means 6, on the basis of the bits of information deposited in the storing means 6, cannot detect a suitable connecting path to an adjacent switching equipment 2, 3, for which the switching equipment 1 has been configured as "assigning exchange", namely for which the switching equipment 1 is authorized for providing a transmission channel and for occupying bandwidth. As a result thereof, the switching equipment 1 must act as "non-assigning exchange" and must inquire one of the adjacent switching equipments 2, 3 about bandwidth. In order to select a suitable switching equipment, the control means access the bits of information deposited in the storing means 16 (shadow bandwidth pool) and detect an adjacent switching equipment 2, 3 that is highly likely to provide sufficient resources for the present connection setup. As it has already been explained, merely the connecting paths of the switching equipment 1, regarding which connecting paths the switching equipment 1 is not authorized for allocating a transmission channel and for occupying bandwidth, are considered in the storing means 16. In the present case, this is particularly the case with respect to the connecting paths 12 - 15. According to Figure 1, it is stored, for example, that 2 transmission channels VCI-C and VCI-D, which occupy a total of 90 % of the resources available on the connecting path 12, have already been allocated by the switching equipment 2 for the connecting path 12. As a result thereof, the connecting path 12 cannot be taken into consideration for the present connection request. On the other hand, two transmission channels VCI-E and VCI-F, which

momentarily merely occupy 30 % of the resources available on this connecting path, have been allocated by the switching equipment 2 on the connecting path 13. The control means 6 therefore recognize that the switching equipment 2 is likely to provides sufficient resources (namely in the form of the connecting path 13) for the pending connection request and therefore select the switching equipment 2 as "assigning exchange" for the present connection request. Subsequently, the switching equipment 1 transmits the B-ISUP-forward message IAM ("initial address message") to the switching equipment 2, however, without transmitting an appropriate VPCI information or VCI information at the same time. This occupancy message IAM is subsequently evaluated by means of the switching equipment 2, and the switching equipment 2 checks, on the basis of the bits of information available to it about the connecting paths 12, 13 for [...] it is configured as "assigning exchange", whether a connecting path is, in fact, available that provides sufficient capacities or, respectively, resources for the present connection request. When this is the case, the switching equipment 2 allocates a transmission channel on a suitable connecting path to the present connection request. In the present case, the switching equipment 2, for example, can allocate a transmission channel VCI-G on the connecting path 13. The switching equipment 1, in the form of the first B-ISUP-return message IAA ("initial address acknowledgment"), is subsequently informed by means of the switching equipment 2 regarding bits of information about the selected connecting path and the allocated transmission channel, i.e. that the switching equipment 1 is informed of the values VPCI=13 and VCI=VCI-G by means of the switching equipment 2. The bits of information transmitted by means of the switching equipment 2 to the switching equipment 1 also contain bits of information about the resources occupied by the selected transmission channel, so that the switching equipment 1 or, respectively, its control means 6 can correspondingly update the bits of information deposited in the control means 6.

Should the switching equipment 2, contrary to the assumption of the switching equipment 1, not be able to find an appropriate connecting path after receipt of a corresponding request of the switching equipment 1, the connection request is rejected by the switching equipment 2 in the form of the B-ISUP-return message IAR ("initial address rechecked"). In this case, the switching equipment 1 must select another adjacent switching equipment, which is able to act as "assigning exchange", i.e. that a re-routing is carried out.

Finally, it should be pointed out that, due to the reasons described in the beginning, the switching equipment 1, which becomes active as "non-assigning exchange", is not allowed to utilize the bits of information deposited in the shadow table of the storing means 16 for purposes of accepting a connection and for purposes of allocating a transmission channel. Exclusively the switching equipment, which is configured as "assigning exchange" for the corresponding connecting path, is allowed to decide about the allocation of a transmission channel and the occupancy of a bandwidth.

Switching equipment

Reference character list

1 - 3	switching equipment
4, 5 16	storing means
6	control means
7 - 15	connecting paths